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Patent  
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE  
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

IN RE APPLICATION OF:  
SCHERER

SERIAL NO. : 10/044,502

FILED: JAN. 10, 2002

FOR: A COMPACT ELECTRICALLY  
AND OPTICALLY PUMPED MULTI-  
WAVELENGTH NANOCavity  
LASER, MODULATOR AND  
DETECTOR ARRAYS AND METHOD  
OF MAKING THE SAME

APPEAL BRIEF BY APPLICANT

(1) *Real Party In Interest.*

The real party in interest is the Trustees of the California Institute of Technology,  
Pasadena, California.

(2) *Related Appeals and Interferences.*

There are no other appeals or interferences known to appellant, the appellant's  
legal representative, or assignee which will directly affect or be directly affected by or  
have a bearing on the Board's decision in the pending appeal.

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(3) *Status of Claims.*

Claims 1 – 20 were original in the application, have been amended and are appealed.

(4) *Status of Amendments.*

Two amendments were filed after final rejection. Neither amendment after final was entered.

(5) *Summary of Invention.*

The invention is defined as a compact electrically and optically pumped multiwavelength nanocavity array 10 as shown in Fig. 2a comprising a plurality of nanocavities 14 as shown in Fig. 2b. Each nanocavity 14 is defined in a photonic crystal 11 where each nanocavity 14 is lithographically formed to define a corresponding predetermined spectral response of each nanocavity 14. The plurality of nanocavities form the array. The spectral response which is lithographically formed defines wavelength supported by the nanocavity 14. The spectral response which is lithographically formed may also define polarization supported by the nanocavity 14. Specification, page 4, lines 3 – 10.

(6) *Issues.*

A concise statement of the issues presented for review.

(7) *Grouping of claims.*

Without prejudice to the separate patentability of each of the claims, all claims depend directly or indirectly on claim 1. The claims do not stand or fall together. A first

group, claims 1 – 5, 7 – 14 and 16 – 20 were rejected as a group as being anticipated by **Painter**, Science Vol. 284. A second group, claims 6 and 15 were rejected as a group as being obvious over **Painter** and **Tanguay** U.S. Patent 5,568,574.

(8) *Argument.*

(a) *35 USC 112 Rejection*

Claims 1 - 20 were rejected as being indefinite.

(i) *Nanocavity, Nanocavity Array, and Patterned Array*

Regarding claim 1, the Examiner contends that the phrase " nanocavity array ", and "predetermined spectral response" render the claim indefinite because it is unclear what is "nanocavity" means. The Examiner argues that the claim does not recite laser structure, and therefore does not appear to understand how the claim can define a nanocavity. It is not clear to the Examiner how to lithographically form the nanocavity to define a predetermined spectral response of each nanocavity.

The term, "nanocavity array" is not literally used in claim 1. What is claimed is "a patterned array of nanocavities". The invention is not a laser, but "a photonic device", which can be understood to be a photonic element, which is part of a laser or larger optical apparatus. The device may be used in any one of a number of different types of electrooptic photonic devices, including but not limited to lasers, modulators, detectors, routers, gates or spectrometers for wavelength and time division multiplexing applications. (Specification, page 9, line 21; page 10 lines 3 - 4).

The device comprises "a plurality of nanocavities". The "plurality of nanocavities" form "a patterned array of nanocavities". There is no lack of clarity about the general

concept of a patterned array of objects. A checkerboard is a patterned array of red and black squares. A dozen eggs for a patterned array of eggs in a carton. Atoms form a patterned array in a crystal and so forth. Here the plurality of nanocavities form a patterned array.

The Examiner contended in a subsequent telephonic interview that “a patterned array of nanocavities” includes even a random collection of defects, nanocavities or cavities in a photonic crystal. This is clearly contrary to the plain meaning of the words in the claim. Merriam-Webster Unabridged dictionary defines “pattern” as “a discernible coherent system based on the intended interrelationship of component parts.” “Array” is defined as “a regular and imposing grouping or arrangement.” A “patterned array” of cavities or a discernible coherent system of cavities based on the intended interrelationship of component parts in a regular and imposing grouping or arrangement is clearly not a random collection of cavities.

What is a nanocavity in a photonic crystal is unquestionably clear, particularly since in this record the primary reference, **Painter**, is being cited for showing a microcavity in a photonic crystal. Fig. 1a of the specification shows a single defect nanocavity, or microcavity or simply cavity, which is identical to Fig. 3 in **Painter**, who is one of the coinventors here. It should be transparently clear that what Painter is calling a nanocavity in the present specification is identical to what Painter calls a microcavity in the prior art. The prefixes “micro” and “nano” are elementary and universally understood terms. Thus, there can be no indefiniteness about what a nanocavity or cavity is in this context, a cavity in which the size is measured in nanometers. An optical cavity is part of the operative combination of a laser and many other optical

devices. Here the optical cavity is of the order of the wavelength of light, i.e. a microcavity or more properly a nanocavity since the dimensions of the cavities as in **Painter** are conveniently measured in nanometers, e.g. a mode volume of  $30\text{nm}^3$  (page 8, line 2).

The Examiner contends that it is not clear how to lithographically form the nanocavity to define a predetermined spectral response of each nanocavity. It is infamous that an optical cavity in a laser significantly affects the mode of light which the laser produces. The nanocavities are described in the specification shown as omitted holes in an array of holes forming the photonic crystal, Fig. 1a and 1b and/or differently sized holes in the array, Figs. 6a – 6c, and/or filled holes in the array, (page 10, lines 7 – 14) and/or altered positions of holes in the array. Defects in the array affect that optical property of the array and define optical cavities of the size of the defect. See for example, page 3, line 14; page 5, line 21; page 6, line 10; page 7, line 10; page 8, lines 12 – 13; and page 9, line 12. This is also clearly taught by **Painter**. See also **Lin et.al.**, “Direct Measurement of the Quality Factor in a Two-Dimensional Photonic-Crystal Microcavity,” *Optics Letters*, Vol. 16, No. 23, (2001); **Zhou et.al.**, “Electrically Injected Single-Defect Photonic Bandgap Surface-Emitting Laser at Room Temperature,” *Electronics Letters*, Vol. 36, no 18 (2000); **Joannopoulos et.al.**, “Tunable Microcavity and Method of Using Nonlinear Materials in a Photonic Crystal” U.S. Patent 6,058,127 (2000).

It cannot be sustained that “nanocavities”, “microcavities” or “cavities” *per se* in semiconductor devices are not known, or how they are fabricated in the photonic crystal, and how they affect the optical properties or spectral response of the

semiconductor device is not readily understood or is beyond the skill in the art.

*(ii) Modulator*

Regarding claim 9, the Examiner contends that the word "modulator" renders the claim indefinite because it is unclear what is "modulator". The Examiner contends that claim fails to recite the structure of modulator. A modulator is a well known photonic device, which takes an input signal and modulates it with a modulating signal to produce an output signal which has a form which is the input signal modulated by the modulating signal. It is clear that all that is being claimed is that the improvement is being used in a modulator. What is being claimed is an improvement in optical cavities which are used in various photonic devices, which here are claimed to include modulators. It is not necessary to claim the structure of every modulator devisable in order to claim the use of the improvement in one of them.

*(iii) Quantum Well*

Regarding claim 10, the Examiner next contends the phrase that the "crystal is formed in active quantum well photonic well material" renders the claim indefinite in that it is not clear to the Examiner how to form an active quantum well material. The applicants do not literally use the phrase, "active quantum well photonic well material." Again, what is an "active quantum well" is notoriously well known and how to form an array of holes in such material is clear, i.e. the same way in which the photonic crystal is formed in any material. The phrase "active quantum well" is used in a large number of Patents and literature references.

*(iv) Means for Changing Optical or Electrical Properties*

Regarding claim 16, the Examiner contends that the phrase " means for changing optical or electrical properties of said nonlinear optical material" renders the claim indefinite because it is not clear how to provide optical or electrical {sic – changes}. The specification at page 4, line 20 – 24 states:

"The array further comprises means for changing optical or electrical properties of the nonlinear optical material in each of the nanocavities, such as electrodes for applying a voltage or current across the array. "

The means is enabled in the specification and the Examiner cannot as a matter of law use 35 USC 112 to reject a functionally defined means, which in pertinent part provides:

"An element in a claim for a combination may be expressed as a means or step for performing a specified function **without the recital of structure, material, or acts in support thereof**, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof. " (emphasis added)

*(v) Estoppel Arising from Refusal to Responsive Enter Amendment After Final*

In the final rejection the Examiner held that the applicant argued that the nanocavity was a defect in the array of holes forming the photonic crystal, but did not have language in claim 1 to that effect. First, the state of the art is such that what constitutes a nanocavity in a photonic crystal is clear. A nanocavity in a photonic crystal is well known and is shown for example in **Painter**. Further explaining that such a nanocavity is considered as a defect in the photonic crystal is wholly unnecessary to convey to one with ordinary skill in the art what a nanocavity is. Second, the applicant offered an amendment after final which was specifically responsive to this ground of rejection to put the claims into a better condition for appeal, which amendment after final was refused entry.

The Examiner should be estopped from arguing that the claim language fails to claim a defect in the array of holes from which a nanocavity may be fabricated, when the Examiner refuses to enter curative amendments offered after final rejection to provide language of the claims in a better form for appeal. In other words, if the lack of certain claim language serves as a basis for final rejection of a claim, then an amendment of the claim offered for purposes of appeal must be entered to provide such language or such lack of language must be held as not supporting an alleged ground for final rejection which can be appealed. The Examiner cannot formulate a section 112 - 2d paragraph ground for rejection and then refuse to enter a legitimate amendment directed to that ground as a means of assuring the Examiner's own success over the applicant.

*(b) Rejection Pursuant to 35 USC § 102*

What **Painter** does not show is anything like Figs. 2a and 2b, which depict an array of nanocavities or microcavities or cavities. The Examiner repeats the earlier rejection that **Painter** discloses a single nanocavity or microcavity in a photonic crystal. It mischaracterizes **Painter** to assert that it teaches an array of such nanocavities or microcavities in a photonic crystal. The holes which comprise the photonic crystal pattern are not the nanocavities or microcavities. The holes in the semiconductor material define the photonic crystal and it is the *lack or absence of a hole in a position where one would normally be expected that defines the defect, nanocavity or microcavity in a photonic crystal.*

It cannot be sustained that **Painter** discloses a patterned array of nanocavities



when **Painter** only discloses one cavity in the photonic crystal.

*(c) Rejection Pursuant to 35 U.S.C. § 103*

The Examiner repeats the earlier rejection of claims 6 and 15 as obvious over **Painter**. The mere knowledge that detectors exist as disclosed by **Tanguay, Jr** U.S. Patent 5,568,574 does not suggest or motivate creating an array of nanocavities in anything, including a detector.

The Examiner cites **Painter** as stating, "the ability to fabricate compact lateral microcavities is important" (p 1820, first paragraph). This is a statement in the grammatical plural used as a rhetorical statement of importance and is not in any way a statement of what **Painter** actually did. One could similarly state that "cures to cancer are important", or "vacations in warm climates are popular", but it does not mean that the writer has found any or even one cure to cancer or ever took one or more vacations to a warm climate. The very sentence prior to the one the Examiner relies on to reject the claims states:

"We describe initial experimental results of a type of microcavity laser in which light is confined to a **single defect** of a nanofabricated two-dimensional (2D) photonic crystal." (emphasis added)

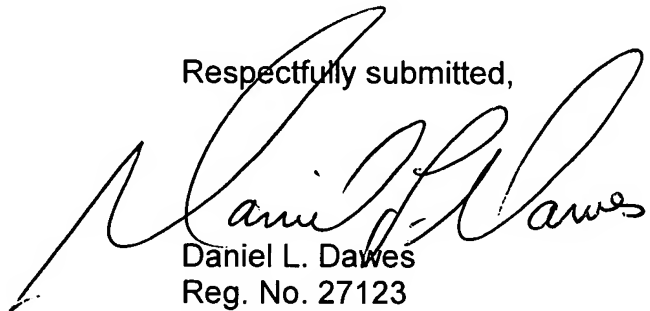
If the light is confined to a single defect of a nanofabricated two-dimensional (2D) photonic crystal, it must be confined to a single microcavity, otherwise it would be confined to multiple defects and furthermore the multiple defects themselves would have to be organized to form a patterned array of cavities, which in turn has an effect on

the optical performance of the device, i.e. a higher order affect than just a single defect or microcavity. A fair reading of **Painter** clearly demonstrates that **Painter** does not contemplate forming multiple defects or cavities into patterned arrays.

The mere existence of two photonic semiconductor detectors 76a, 76b as taught by **Tanguay** in Figs. 10 and 11 does not motivate using a patterned array of nanocavities in a photonic detector. Characterizing two detectors 76a, 76b as an array is also stretching. When **Painter** fails to teach a patterned array of nanocavities, **Tanguay** does not then make it obvious to use a patterned array of nanocavities in a detector by showing two semiconductor optical detectors 76a, 76b on a chip surface 72, when **Tanguay** has nothing whatsoever to do with a patterned array of nanocavities.

**Tanguay's** detector is not fabricated in a photonic crystal, never contemplates any cavity of any kind in a photonic crystal and does not in any way consider the nature of a photonic cavity other than to mention than implicitly in the mention of an inverted cavity compound semiconductor multiple quantum well modulator, which is an entirely distinct physical structure than an array of defects in a photonic crystal.

Respectfully submitted,

A handwritten signature in black ink, appearing to read "Daniel L. Dawes", is written over the typed name and contact information.

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## APPENDIX

1        1. A compact electromagnetically pumped multiwavelength photonic device  
2        comprising a plurality of nanocavities, each nanocavity defined in a photonic crystal  
3        in which each nanocavity is lithographically formed to define a corresponding  
4        predetermined spectral response of each nanocavity, said plurality of nanocavities  
5        forming a patterned array of nanocavities.

1        2. The photonic device of claim 1 where said spectral response of each nanocavity  
2        is defined by the wavelength of the electromagnetic wave which is supported in the  
3        photonic crystal by said lithographically defined nanocavity.

1        3. The photonic device of claim 1 where said spectral response of each nanocavity  
2        is defined by the polarization of the electromagnetic wave which is supported by said  
3        lithographically defined nanocavity.

1        4. The photonic device of claim 1 where said spectral response of each nanocavity  
2        is defined by the polarization and wavelength of the electromagnetic wave which is  
3        supported by said lithographically defined nanocavity.

1        5. The photonic device of claim 1 where the photonic device comprises a laser and  
2        wherein said array of nanocavities is employed in the laser.

1        6. The photonic device of claim 1 where the photonic device comprises a detector  
2        and wherein said array of nanocavities is employed in the detector.

1        7. The photonic device of claim 1 where the photonic device comprises an optical  
2        gate and wherein said array of nanocavities is employed in the all optical gate.

1        8. The photonic device of claim 1 where the photonic device comprises an all  
2        optical router and wherein said array of nanocavities is employed in the all optical  
3        router.

1        9. The photonic device of claim 1 where the photonic device comprises a modulator  
2        and wherein said array of nanocavities is employed in the modulator.

1        10.        The photonic device of claim 1 wherein an active quantum well is included  
2        in the photonic device and wherein said photonic crystal in which the array of  
3        nanocavities are defined is formed in the active quantum well.

1        11.        The photonic device of claim 1 where the photonic device comprises a  
2        vertical cavity surface emitting laser and wherein said array of nanocavities is  
3        employed in the vertical cavity surface emitting lasers, VCSELs.

1 12. The photonic device of claim 11 wherein said nanocavities each have a volume  
2 and wherein said volume of each of said nanocavities is approximately a cubic half-  
3 wavelength ( $\lambda^3/2$ ).

1 13. The photonic device of claim 1 comprises an array of lasers each including an  
2 array of nanocavities and where at least one nanocavity laser is used as a pump for  
3 an adjacent nanocavity laser.

1 14. The photonic device of claim 1 further comprising a nonlinear optical material  
2 filling said holes in the photonic crystal in which the array of nanocavities are  
3 defined.

1 15. The photonic device of claim 14 wherein said photonic device with the  
2 array of nanocavities defined in the filled photonic crystal comprises a tunable  
3 nanocavity laser, detector, router, gate or spectrometer array.

1 16. The photonic device of claim 14 further comprising means for changing optical or  
2 electrical properties of said nonlinear optical material in each of said nanocavities.

1 17. The photonic device of claim 1 where said photonic crystals in which said array is  
2 defined comprises a Si-Ge materials on a silicon substrates disposed on an  
3 insulator.

1 18. The photonic device of claim 17 further comprising a silicon slab  
2 waveguide or integrated circuit integrated with said array of nanocavities.

1 19. The photonic device of claim 17 further comprising a nonlinear  
2 optical material filling said photonic crystal and means for changing optical or  
3 electrical properties of said nonlinear optical material surrounding ~~in~~ each of said  
4 nanocavities.

1 20. The photonic device of claim 1 further comprising a waveguiding layer  
2 disposed adjacent to said array of nanocavities, said waveguiding layer being  
3 transparent to light from said array and critically coupled to said nanocavities in  
4 said array.

## CERTIFICATE OF MAILING

I hereby certify that the attached Appeal Brief by Applicant is being deposited with the United States Postal Service as First Class Mail postage prepaid in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on Jan. 15, 2004.

  
Nancy V. McElrath

1-15-04

Date